

height alignment. The jacks are placed on two steel pedestals grouted to the floor. Aluminum spacers or steel plates are used between the magnets and the girder, except for the middle quadrupole, which is mounted on smaller wedge jacks for height adjustment.

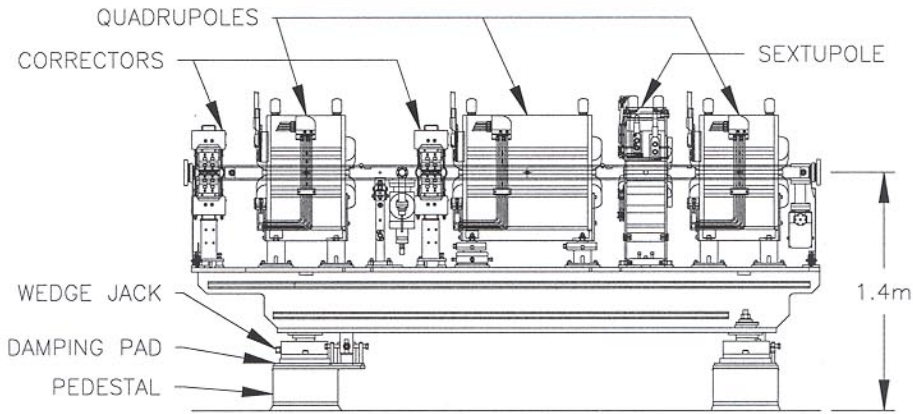


Fig.1: An APS girder-magnet assembly

The wedge jacks are the weak structural links of the girder-magnet assembly. With centers of mass of the magnets approximately 1 m away from the main jacks, the entire assemble is subjected to torsional vibrations (resembling an inverted pendulum) in the fundamental mode. Moving the alignment jacks as close to the magnets as possible can reduce vibration amplitudes; however, with magnet-girder assemblies already built, this option was impractical at the APS.

Extensive vibration measurements showed that the quadrupoles' rms displacements in 4-50 Hz band varied from 200 nm to 500 nm. The wide difference in values was due to construction activities at the site and flow-induced vibrations of water headers. The lower values were obtained during quiet nights with ground rms displacement of about 25 nm and with water-headers rigidly attached to the ceiling.

Following experimental evaluations of several damping methods, viscoelastic pads were selected to reduce the vibration levels. The pads, 12" x 8" in size, consist of three 1/16" stainless steel plates joined by pressure-sensitive adhesive films of proprietary acrylic materials. Relative motion between the stainless steel plates induces large cyclic shear strains in the films resulting in substantial energy dissipation. Anatrol 217 [4] damping material (in the form of 0.006" adhesive films) was selected for the APS damping pads for reasons of its performance, cost and availability.

The performance of the damping pads was evaluated during the initial installation in 1994, and subsequently during a maintenance shutdown in December 1999. Vibration studies in 1994 were conducted with and without the damping pads. In 1999 the tests were done only with the installed damping pads since the pads could not be removed within the APS operational constraints. For these three cases, the PSD (power spectral density) of horizontal displacement of a quadrupole magnet is plotted in Fig. 2. Without the damping pads under the wedge jacks, the peak value of PSD, measured in 1994, was $2.3 \times 10^{-4} \text{ nm}^2/\text{Hz}$. It reduced by a factor of 10, to $2.3 \times 10^{-5} \text{ nm}^2/\text{Hz}$, with the